Development of Grating Technology for High-Resolution Spectrometers Using Nanofabrication Techniques

Completed Technology Project (2017 - 2021)

Project Introduction

Several of astronomy's key future science objectives as identified by NASA can be achieved with soft X-ray spectroscopy. This study seeks to develop a new technique for fabricating X-ray reflection gratings to be integrated in future X-ray spectrometer designs. The fabrication method developed in this study will create a reflection grating with a true radial profile, which is a requirement in order to eliminate grating-induced aberrations to the telescope focus and achieve the required resolving power of future missions. If successful, the technology developed in this study will lead to the realization of theoretical X-ray spectrometer performance on timescales consistent with the next decadal survey. This study will build on our research group's strong heritage in the development of X-ray reflection gratings and introduce a new fabrication technique that retains current state-of-the-art grating efficiency while also achieving order-of-magnitude improvements in resolving power. The new fabrication technique is centered around piezoelectric materials and will be approached as follows: first, I will model grating applications of piezoelectric materials and conduct trade-study to determine most suitable piezoelectric materials to be used in grating fabrication. I will then obtain materials and begin implementation of the planned fabrication procedures: create a "master" grating with parallel grooves current electron-beam lithography (EBL) employed in our grating fabrication efforts in order to retain the precise groove facets achievable with EBL; the EBL "master" will then be imprinted into a soft resist that is coated upon a wafer of piezoelectric material, beneath which are electrodes to control the current through the material; with the parallel-groove profile imprinted into the resist, a variable current will be applied across the piezoelectric material to force the resist to conform to a pre-selected pattern, which will transform the parallel grooves into a radial profile without sacrificing the precise facets introduced in the original EBL write; the pattern will then be UV-cured in order to solidify the resist and lock the radial profile into place; finally, this new piezoelectric master will be used to imprint dozens of replicas. The entire process will certainly require a significant amount of development and trial-and-error, which includes testing intermediate prototypes at NASA centers for both efficiency and resolution. However, if implemented successfully, this technology will make possible both the order-of-magnitude gains in effective area and resolving power over current observatories that is required for future X-ray missions.

Anticipated Benefits

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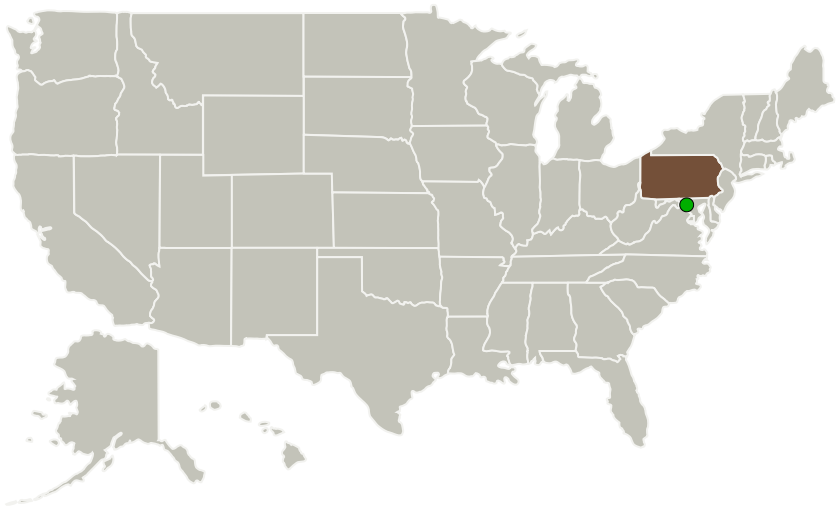
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Pennsylvania State University-Main Campus(Penn State)	Lead Organization	Academia	University Park, Pennsylvania
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Pennsylvania

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Pennsylvania State University-Main Campus (Penn State)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Randall Mcentaffer

Co-Investigator:

Drew Miles

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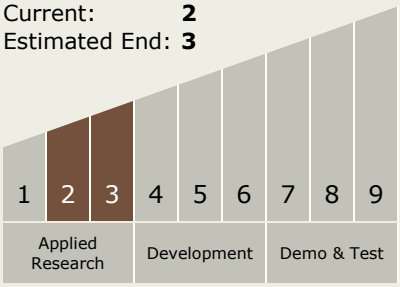
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX02 Flight Computing and Avionics
  - TX02.3 Avionics Tools, Models, and Analysis
    - TX02.3.3 Avionics Reliability and Fault-Tolerance Analysis and Modeling

Target Destinations

Earth, The Moon, Mars